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ABSTRACT

In this study, which involved 87 freshman English students at Brigham Young University, the variety of practice items and the strategy of Practice (convergent or divergent) were systematically varied, in order to assess their effects on a rule-finding task. The task was presented in an expository fashion, using both rules and practice, and in a discovery format, using practice only. Previous research indicates that the discovery mode facilitates transfer, but not retention, of knowledge. Conversely, it has been found that the expository mode facilitates retention but impedes transfer. Data collected in this study reveal that the amount and type of rule divergence, not the mode of presentation, are the crucial factors in Producing transfer of learning. Thus, the expository mode of presentation can be just as effective in producing transfer learning as is the discovery mode, if divergence in the Practice strategy is provided. Likewise, the performance levels attained with both modes of presentation are greatly reduced if the degree of practice-strategy divergence is restricted. (Author/KS)

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The Effects of Practice-Item Variety, Practice Strategy and Training Mode on Performance in a Rule-Finding Task

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Abstract

In a study involving 87 Freshman English students at Brigham Young University, the variety of practice items and the strategy of practice (convergent vs. divergent) were systematically varied to investigate their effects on a rule finding task using both expository (rules + practice) and discovery (practice only) modes of training. Convergent practice consisted of practice involving closely related practice items, while divergent practice consisted of practice involving rules more distantly related. Previous research (Guthrie, 1967) had shown that the discovery mode appears to facilitate transfer, but not retention and that the expository mode facilitates retention, but impedes remote transfer. The results of the present study indicate that the amount and type of exposure to rule divergence is the important factor in producing transfer learning and not the presentation mode (discovery versus expository). The expository presentation mode can be just as effective in producing transfer learning as the discovery mode if divergence in the practice strategy is provided. Likewise the performance with both presentation modes is greatly reduced if the degree of practice-strategy divergence is restricted. The limits of the advantage of increasing exposure to divergent rules were also explored.

It has been widely held that retention learning is fostered by training with instructional materials containing rules plus practice (Craig, 1956; Haselrud & Meyers, 1958; Kritell, 1957; Wittrich, 1963), while transfer learning is fostered by training in the so called "discovery" mode which includes practice with examples, but excludes a presentation of the rules involved (Brunen, 1961; Suchman, 1961; Gagne and Brown, 1961). However, the evidence for the superiority of the discovery mode in producing transfer learning has been equivocal. The most definitive study to date seems to be one published by John Guthrie in 1967.

The Guthrie study used three training modes to teach college seniors how to decipher cryptograms (disguised words): (1) a rule-example (expository) mode, (2) an example-rule mode, and (3) an example-only (discovery) mode. The test consisted of three different types of tasks: (1) retention tasks, (2) near transfer tasks and (3) remote transfer tasks. On the retention tasks, the rule-example group was superior to all other groups including a no-training control group and the other groups did not differ. On the near transfer tasks, the example-only group and the example-rule group were superior to the control and to the rule-example groups, but did not differ from each other. On the remote transfer task, the example-only group was superior to all others, the example-rule and no training groups did not differ, and the rule-example group was inferior to the others. Guthrie concluded that "the discovery method appears to facilitate transfer, but not retention" and that "expository instruction facilitates retention, but impedes remote transfer."

The implication that an expository presentation mode is not effective for remote transfer learning is unwarranted on the basis of the

evidence provided. The study is biased against the expository presentation mode by the fact that only convergent rules were taught and by the fact that the rule-example group likely received fewer practice items than did the other groups. Divergence of rules and practice items, practice strategy and the number of rules and practice items are likely much more important factors in facilitating far transfer than is the presentation mode (discovery versus expository). Indeed from the results of this study it might be argued that the example-only and the example-rule groups learned little from the training that they didn't already know. Their performance over the control group (which incidentally might be construed merely as a discovery group with less practice time) might be due purely to practice at trying to decipher cryptograms on their own. On the other hand, the inferior performance of the expository group may very well be an artifact of interference due to the learning of an irrelevant set of rules with no chance to practice any of the skills that might be useful in the transfer tasks.

The present experiment was designed to test the possibility that the expository presentation mode might be made more effective in enhancing far transfer learning if the subjects were provided exposure to divergent rules, divergent practice and greater numbers of rules. If these variables are the important ones in producing effective far transfer learning, then we should be able to show: (1) that by increasing the exposure to divergent rules and/or divergent practice we are able to increase the scores of the subjects in the expository groups and (2) that by reducing the exposure to divergent rules and/or divergent practice we are able to reduce the score of subjects in the discovery groups.

In the present experiment we were more interested in the effects of the type of practice than we were in the amount of practice; therefore,

we held the number of practice instances constant for all the different treatments in practice strategy.

In a pilot study we found that solving individual cryptograms was a very easy task for most students. To avoid a possible ceiling effect, we decided to change the task into a more difficult rule finding one. This proved to be a more effective task in discriminating differences between the different practice strategies. We also decided to eliminate Guthrie's example-rule group from the present study because in five of the six comparisons made by Guthrie between the example-only group and the example-rule group, the two groups were not significantly different from each other.

We hypothesized then that performance on a transfer task will be improved using the expository presentation mode, just as it is using the discovery mode, when some degree of divergence in the practice strategy is provided and that performance on a transfer task will be reduced using the discovery presentation mode, just as it is using the expository mode, when the degree of divergence in practice strategy is restricted.

We also thought it likely that improved performance with increasing exposure to divergent rules will occur only up to an optimal point and that beyond this point performance will decrease due to the inability of the subjects to handle excessive numbers of rules. In an effort to find this point for the rule finding task used in this experiment, we provided a range of exposure from three to nine rules.

It is also likely that performance will improve with a certain amount of convergent practice within each category of rules presented. Therefore, we provided a range of convergent practice instances from three for each rule category to eighteen for one of the categories. In a similar manner we varied the exposure to divergent practice from nine

to eighteen instances to correspond to the varying degrees of convergent practice while maintaining the total number of practice instances used for all groups at eighteen.

METHOD

Materials

The task selected for the study was a rule finding task that involved finding a common solution rule that could be used to solve all three cryptograms of a triplet set. As in the Guthrie study, a cryptogram for the present study was a work that had been altered in some way to disguise it.

The rules for solving the cryptograms consisted of three main categories: addition, substitution and transposition. The rules were similar to the ones employed by Guthrie, but were expanded to include the new category of addition which was not employed by Guthrie. Below are listed examples of a rule from each category:

Addition: Add an "S" to each word.

Substitution: Change the fourth letter to the one preceding it in the alphabet.

Transposition: Reverse the order of the first three letters of the word.

The above examples happen to be the ones that were used for practice treatment IV.

The rules for each practice segment were located on the page in the training booklet immediately preceding the first practice page of that segment. Each page of practice instances consisted of three triplet sets of crytograms, a blank after each cryptogram to fill in the solutions

to each cryptogram, and a blank after each triplet to write in the rule that provided the solution to each of the cryptograms in the triplet. The subjects were instructed to be as specific as possible in writing the solution rules.

Treatments

There were six main treatment conditions which systematically varied the number and types of practice instances or examples to which each group was exposed. The types varied from 1 to 3 categories. The number of instances presented to each student was held constant (18 instances) as was the content of the instances as far as possible, so that the type of practice, and not the amount of practice, was the manipulated variable. Practice within one type of example was termed convergent practice (CP), while practice with more than one type of example was termed divergent practice (DP). The most purely convergent practice group (Group I) was exposed to only one type of example, while the most purely divergent practice group (Group IV) was exposed to three types of examples and no convergent practice. The other four groups were mixed practice groups having varying degrees of convergent and divergent practice.

Table 1 gives a brief description of the six types of practice as they were constituted in the expository presentation mode to give the reader an idea of the differences between practice groups. Groups I and III were labled as having only convergent practice, although they were exposed to divergent solution categories, because their practice was always within categories and never across categories. Both the convergent practice and the divergent practice consisted of equal numbers of practice instances from each rule preceding them. The practice cr

inquisitory instances (Ieg's) within each practice segment were randomly arranged so that the subjects would have to look at the instances to identify the rule which governed each.

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Insert Table 1 about here

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The discover presentation mode consisted of exactly the same instances as in the expository mode, however the rules were not provided before each practice segment. The subjects were instructed to discover the rule that applied to each instance.

Tests

Each student took an identical test which consisted of twelve randomly ordered cryptogram triplets--three sets for each of four different solution categories. Three of the categories were those used in the various training groups (illustrated in Table 1) and the fourth was a deletion category. The test was designed to replicate each of Guthries's learning tasks: rentention, near-transfer and far transfer.

The retention task consisted of the three triplets from the addition category. Although the addition cryptograms were ones that had not been encountered before, each addition triplet had as its solution one of the three addition rules previously encountered in training. Only practice group IV had a retention task slightly different from the other groups. The exact nature of this difference can be inferred from Figure 1 and will be explored in more detail in the Discussion section of this paper.

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Insert Figure 1 about here

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The near transfer task was realized whenever the subject had training in a particular solution category and was tested in that category by cryptograms requiring a solution rule from that category, but not a solution rule identical to one already encountered. An exact breakdown of the near transfer cells can be seen in Figure 1.

The far transfer task was realized whenever the subject was tested by a solution category that he had not previously encountered (see Figure 1).

Procedures

Three different procedures were used for scoring the tests: the first allowed six points for each triplet (one point for each of the three cryptomgrams and one to three points for the rule, depending on the degree of specificity of the rule), the second allowed only the three points for the degree of rule specificity from the first procedure, and the third was an all or none scoring procedure in which one point was awarded for the rule only if it received at least two points in the second scoring procedure. Thus, the first scoring procedure allowed points for a preliminary problem solving task very similar to the one used in the Guthrie study as well as for the rule finding task, while the second and third scoring procedures allowed points only for performing the rule finding task.

Design

The 2 x 6 x 4 factorial design is diagramed in Figure 1. The third factor (the 4 solution categories on the test) consists of repeated measures on the same subjects in each of the other twelve conditions.

Subjects

The subjects were 87 freshmen English students at Brigham Young University who participated in the experiment during one of their normally scheduled class periods. The students were randomly assigned to one of the

twelve conditions as they entered the classroom and each was allowed to work through his training booklet and test at his own rate. Seven students were excluded from the data analysis because they did not complete more than two pages of the four-page test.

RESULTS

A multivariate analysis of variance for unequal cells was run on the three factors using as dependent variables the scores resulting from the three different scoring procedures. Then separate univariate analyses were made using each dependent variable. A split plot model ($Yijkl = y + Ai + Bj + ABij + S(ij)k + Cl = ACil + BCjl + ABCijl + E$) was used with the same subjects for each practice group (factor B) serving as subjects for each solution category (factor C).

The multivariate analysis showed significant differences for all of the main effects except presentation mode, for all of the two-way interactions and for the three-way interaction. The effects for practice strategy ($U = .6138084$, $df = 5/68$; $F = 2.354$, $df = 15/182.6$) and solution category ($U = .4696037$, $df = 3/204$; $F = 19.901$, $df = 9/491.8$) the presentation-mode x solution-category interaction ($U = 0.7961647$, $df = 3/204$; $F = 5.365$, $df = 9/491.8$), the practice-strategy x solution-category interaction ($U = 0.4430116$, $df = 15/204$: $F = 4.210$, $df = 45/600.9$) and the presentation-mode x practice-strategy x solution-category interaction ($U = 0.6640837$, $df = 15/204$; $F = 1.973$, $df = 45/600.9$) were all significant beyond the .01 level of probability. Although the presentation-mode x practice-strategy did not reach significance by the U-statistic, it was significant using the F-statistic ($F = 1.700$, $df = 15/182.6$, $p = .05$).

Although the three univariate analyses all yielded similar results, the scoring procedure giving credit for rule specificity as well as indivi-

dual cryptogram solutions seemed to discriminate most effectively the differences among the various independent variables. [(Rule + crypograms = 6) > (Rule = 3) > (Rule = 1).] Therefore, only the results of this analysis will be reported in detail here with occasional allusions to contribution from the other two analyses.

The univariate analysis showed the most highly significant effect for solution category ($F = 28.54$, $df = 3/204$, $p < .01$). The main effect for practice strategy ($F = 5.38$, $df = 5/68$, $p < .01$), the presentation-mode x solution-category interaction ($F = 7.35$, $df = 3/204$, $p < .01$) and the practice-strategy x solution-category interaction ($F = 2.59$, $df = 15/204$, $p < .01$) were also significant as in the multivariate analysis. However, the presentation-mode x practice-strategy interaction and the three way interaction were not significant in any of the univariate analyses, although both were significant in the multivariate analysis.

A Newman-Keuls Sequential Range analysis was used to interpret the main effects and a Duncans New Multiple Range analysis was used to interpret the interactions. The Newman-Keuls Sequential Range analysis of the practice-strategy effect showed that strategy II (convergent practice with two rule types) is significantly better ($p < .01$) than all other strategies in achieving overall effectiveness in finding rule solutions for cryptograms. None of the other means were significantly different from each other.

The Newman-Keuls analysis of the solution-category effect indicates that significantly more subjects ($p < .01$) are able to find addition rules than are able to find any other type and that significantly fewer ($p < .01$) are able to find transposition rules. The relationships of the solutions found under each category can be represented as follows: addition (mean = 8.400) > deletion (5.212) = substitution (4.912) > transposition (2.554).

The Duncans New Multiple Range Analysis of the presentation x solution interaction indicates that those trained with the expository presentation mode find significantly more ($p < .01$) solutions in the addition category than in any other solution category and that they find significantly more solutions in this category than do any of those trained with the discovery presentation mode no matter which solution category is considered (see Table 2). Those trained with the expository presentation mode also find significantly more ($p < .01$ & $p < .05$ respectively) solutions in the substitution category than they do in the transposition and deletion categories.

Insert Table 2 about here

Those trained with the discovery presentation mode find significantly more solutions in both the addition and deletion categories than they do in the transposition and substitution categories ($p < .01$ & $p < .05$ respectively, see Table 2).

The most interesting presentation x solution interactions, however, are those between the two presentation modes in the addition and in the deletion categories. The number of solutions found in the addition category by those trained with the expository mode is significantly greater ($p < .01$) than the number found by those trained with the discovery mode, while in the deletion category the number of solutions found by those trained with the discovery mode is significantly greater ($p < .05$) than the number found by those trained in the expository mode (see Table 2). Since the addition solutions are essentially all retention solutions and since the deletion solutions are all far transfer solutions, these differences must be attributed to the general superiority of the expository presentation

mode in retention learning and the general superiority of the discovery mode in far transfer learning. This confirms the results reported by Guthrie in 1967. Although those trained with the discovery mode perform significantly better on far transfer items than do those trained in the expository mode, this advantage in the far transfer task is not enough to overcome the advantage in the retention task of those trained with the expository mode. In other words those trained with the expository mode do better in their specialty (retention learning) than those trained with the discovery mode do in theirs (far transfer learning).

The Duncans analysis of the practice x solution interaction showed that there were many significant differences. All of these differences important to our hypotheses are reported in Table 3 with their respective significance levels. Only some of the more interesting differences are mentioned here with possible explanations for these differences suggested in the Discussion section.

The subjects using practice strategies I and II did significantly better ($p < .01$) on the addition solutions than did the subjects of any other practice strategy group except group III. Likewise in the substitution category group II did significantly better ($p < .01$) than all other groups except group III. In the transposition category, all of the means are reasonably low with none significantly better than any of the others. However, the mean for group VI is very close to being significantly better than most of the others. In the deletion category, group II is once again significantly better ($p < .01$) than all of the other groups. Furthermore, group VI is significantly better ($p < .05$) than group I (see Table 3).

All of the addition means are higher than the means of the other categories and significantly higher than most of the means of their respective

groups. This is especially true for group I where the addition mean is significantly higher ($p < .01$) than all other means (see Table 3).

Insert Table 3 about here

All of the differences from the two-way interactions will make more sense when looked at in the context of the three-way interactions so a detailed discussion will be presented in the Discussion section of this paper.

The presentation x practice x solution interaction likewise had many significant differences and all of these are indicated in Table 4 along with their respective probability levels. A detailed interpretation follows in the Discussion section.

DISCUSSION

The analysis of the presentation mode x practice-strategy interaction considered by itself, clearly supports the conclusions of the Guthrie study. However, when we look closely at the presentation-mode x practice-strategy x solution-category interactions, it becomes obvious that these conclusions are misleading and that our alternative explanation for Guthrie's results is supported. Guthrie's interpretation, though plausible for the data he reports, is not consistent with the additional information added by the three-way interactions.

The analyses of both the practice-strategy main effect and the practice-strategy x solution-category interactions clearly indicate that practice strategy II is significantly better than all other practice strategies in both presentation modes and that it is better for all solution categories except transposition. The levels of significance for these differences are shown in Table 3. The analysis of the three-way interactions further substanciates the superiority of the strategy II and gives more insight into the nature of this superiority (see Table 4).

An examination of the performance of practice group II on both transfer tasks clearly supports our hypothesis that performance on a transfer task will be improved using the expository presentation mode, just as it is using the discovery mode, when some degree of divergence in the practice strategy is provided. The score in the substitution solution category serves as a measure of near transfer for strategy II. Although the near transfer mean (9.2857) is higher for the expository presentation mode than for the discovery mode (mean = 8.8571), this difference is not significant (see Table 4). Nonetheless, the fact that it is equal to the corresponding discovery mean and significantly higher than other near transfer score

means (especially the mean for strategy I) indicates that performance has improved when rules from two divergent solution categories are presented and practiced using the expository mode.

Insert Table 4 about here

The results of the far transfer tasks for practice strategy II likewise tend to confirm the hypothesis. Both the deletion and the transposition solution categories are far transfer tasks for strategy II. Although the mean in the deletion category for the expository mode (7.2857) looks low compared to the corresponding mean of the discovery mode (12.1430), it is not significantly lower (see Table 4). This means that we must consider the means to be equal. Furthermore, this is the best performance for the discovery mode in the entire study. Clearly this is an example of a case where the expository mode of presentation is at least statistically as effective in far transfer learning as is the most successful discovery-mode achievement of the study. Even if we regard the performance of the expository mode in this case as inferior to that of the discovery mode, it is still the highest mean for the expository mode in the deletion category even though it is not statistically higher than most of these other means. In addition, it is statistically higher ($p < .01$) than the corresponding discovery value using strategy I. Clearly it must be regarded as an improvement. Thus, in a far transfer task as well, the introduction of divergence appears to have improved the performance using the expository mode of presentation.

The performance of both presentation modes on the far transfer task in the transposition category is very low, significantly lower than the performance on the corresponding far transfer task in the deletion category (see

Table 4). In line with results of the solution-category main effect analysis, this seems to indicate that the transposition task is significantly more difficult ($p < .01$) than the other tasks at least when presented in the order used in the present study.

Support for our second hypothesis, that performance on a transfer task will be reduced using the discovery presentation mode when the degree of divergence in practice strategy is restricted, is provided by the performance of practice group I. All 18 of the practice triplets from this group were from the addition category and could be solved by one of three rules. The experimentors felt that such a concentrated exposure to one category would likely establish a response set in both groups that would interfere with their finding solutions to cryptogram triplets from any category but addition. This is exactly what happened.

For this practice group all categories but addition were far transfer tasks and every far transfer task was handled in exactly the same way. An examination of the far transfer cell means from Table 4 will show that all of them are very close to each other. An examination of the raw scores is even more revealing. With the discovery mode using the all or none scoring procedure, all seven subjects found not even a single solution in the deletion category, only one found a solution in the substitution category and three found solutions in the transposition category (one student finding two solutions.)

The results were very similar in the expository mode with only one student in eight finding two solutions in the substitution category (the rest finding none), likewise for the transposition category, with two students and finding two solutions in the deletion category.

In the addition category which was a retention task for both presentation modes, subjects outdid the discovery mode two to one when

trained with the expository mode, averaging slightly better than two out of three correct solutions. The discovery group averaged slightly more than one correct solution out of three.

The third hypothesis, that improved performance with increasing exposure to divergent rules will occur only up to an optimal point beyond which it will decline due to the inability of the subjects to remember excessive numbers of rules, was also supported. It appears that for the conditions of this experiment six rules, three from each of two divergent sets, seem to produce the optimal results (see Table 4, practice strategy II), with both the expository mode (total = 31.428) and the discovery mode (total = 35.286), attaining their maximum level of performance under these conditions. Under these conditions the expository group still tends to maintain a slight edge over the discovery group on retention tasks, while the discovery group maintains a slight edge over the expository group on far transfer tasks.

When an additional divergent set of three rules is added as in practice strategy III, performance tends to diminish in all categories, with the retention task diminishing most slowly. However, all three tasks studied by Guthrie tend to be affected differently as the various parameters investigated in the present study are varied. To see more clearly what is going on within each learning task we must simplify the number of variables under consideration.

There is a lot of noise in the data as represented in Table 4. Most of this is due to the fact that the solution categories are not all equally difficult. From a control study that we conducted at the same time as the reported experiment using a control group that received only the test, it was found that solutions from the deletion category are inherently easier

to find ($p < .01$) than are solutions from the other categories, which did not differ significantly from each other. Furthermore, pre-exposure to the addition and substitution categories tends to induce a response set in the subjects that makes the transposition category more difficult than it would otherwise be. These effects could be controlled for in future studies by systematically altering the presentation order as well as the category/task assignments.

However some of this noise can be reduced in the present experiment by considering together all of the cells belonging to each task, thus mixing the substitution and transposition categories among themselves and the deletion category.

To get a more complete picture of how the three transfer tasks are affected using the six practice strategies, we can use the information from the two previously unencountered addition rules in practice group IV to estimate authoritatively the results of a near transfer task for group I.

The results of combining the solution categories into learning tasks, as well as the results of estimating the near-transfer and retention cells for practice strategies I and IV respectively, are graphed in Figure 2 to facilitate interpretation.

For the retention task, both the expository and discovery modes tend to decline in effectiveness as the amount of exposure to divergent-category rules is increased with performance in the discovery group consistently below that of the expository group--though not significantly in the middle ranges of rule divergence (practice groups II, III and IV, see Figure 2). Note that although both practice groups III and VI have training with nine rules with three rules from each of three divergent rule categories, only group VI receives divergent practice during training

(see Table 1). In the expository mode alone this decline never reaches significance and tends to level off in the higher ranges of divergence with large numbers of rules (practice groups III, V, and VI, see Figure 2). Group IV tends to break this trend and will be commented on separately.

The two presentation modes are significantly different from each other in the retention task only for groups I and VI. For both of these practice groups, performance with the discovery presentation mode is significantly below that with the expository mode. In group I only three convergent rules of the addition solution category are presented in training using convergent practice. Apparently this is enough exposure for the discovery group to become familiar with only the general category (addition in this case), but not with the specific rules. In other words in the discovery mode, the retention task becomes identical with the near transfer task. There is no such thing as a retention task in the discovery mode.

This is confirmed by comparing closely the discovery mode curves for both retention and near transfer. As can be readily seen from examining Figure 2, these two curves are nearly identical. At no point is there a significant difference between them (except in group IV which will be discussed later). This explains why the performance with practice group II in the discovery mode is so good. The subjects had successfully identified two solution categories and are able to average about 1 1/2 solutions per category (50% of the possible). When a third category is added, it seems to frustrate the learning of any solution category and performance in all three categories deterioriates to an average level of less than 1/2 solutions per category (see especially group VI in Figure I and Table 4). This effect seems to be more devastating if the amount of convergent practice within each category is reduced and divergent practice is added. Compare

the results of practice groups III and VI. To tease appart the effects of these two variables (convergent and divergent practice) we would need to do another study systematically varying each variable while holding the other constant

With the expository presentation mode, performance on the near transfer task tends to approximate that for both modes on the far transfer task, therefore we will include it in our discussion of the far transfer task.

In far transfer learning both modes of presentation seem to be equally effective using all strategies studied in this experiment except strategy IV which will be discussed later. There are no significant differences between the modes of presentation using any of the practice strategies studied (except strategy IV). Guthrie found significant differences between the modes because he compared the performance of a highly restricted expository group with an unrestricted discovery group. Guthrie's expository group was restricted by exposing them to convergent rules of only one solution category during training. We have shown in the present study that when both modes are correspondingly restricted by excessive exposure to only convergent practice and convergent solution categories, the performance of both modes is very low on a far transfer task (see Figure 2, practice group I). The expository, near transfer group behaves in exactly the same way when restricted by the practice procedures of strategy I. Likewise, the expository, near transfer group behaves the same as the two far transfer groups using all practice strategies (except IV): there are no significant differences in the performance of these three groups (see Figure 2 and the appropriate cells of Table 4).

Now let us examine the performance of these three groups using each of the practice strategies (except IV). As mentioned already, all three groups are significantly inferior in performance on a far transfer task

when trained with the restrictive procedures of strategy I. Likewise all three groups improve when exposed to an additional solution category with convergent practice (practice strategy II). All three groups decline with the addition of a third solution category with only convergent practice (strategy III). Their performance remains the same when the third category is removed, but an excess of divergent practice (with a corresponding reduction of convergent practice) is introduced. The performance of all three groups increases when the third solution category is added again, but this time with an equal amount of convergent and divergent practice per solution category. Perhaps the performance of all three groups could be enhanced even further by increasing the amount of convergent practice within each category and by correspondingly increasing the amount of divergent practice between categories.

It is interesting to note that while the three learning tasks differ in performance from each other using practice strategies III and V, their performance on both tasks remains the same within each training task. This means that the training variables are interacting proportionately with each other for all three learning tasks. A large number of rules (9) and a high level of solution category divergence with a correspondingly high level of convergent practice within each category with no divergent practice seems to be functionally equivalent to a middle range number of rules (6) and a middle range of solution category divergence with a low level of convergent practice within each category and a high level of divergent practice. All learning tasks are proportionately more proficient using strategy II than they are using strategies III and V.

The exact relationships between these variables on the present rule finding task should be discoverable with a series of tightly controlled

experiments. Since this rule finding task is similar in nature to the much more important rule finding task of learning how to learn, it seems that an understanding of the exact relationships between these variables might potentially be very valuable.

Another interesting question remains to be considered: why is the behavior on the near transfer task so different between the two presentation modalities? Using the discovery mode, the near transfer task behaves very much like the discovery-mode retention task. This was mentioned earlier by noting that in the discovery mode there is essentially no retention task, but only a near transfer task. But why is the behavior for the expository near-transfer task so much like that of both far transfer tasks?

The essential difference between both near transfer groups arises in under practice strategies I and VI (see Figure 2). Strategy I is geared for teaching a retention task, while strategy VI is geared for a far transfer task. Both the discovery near-transfer task and the discovery retention task learn essentially the same thing: to distinguish between solution categories. Since a retention task and a near transfer task involve essentially the same solution categories, subjects performing on both the discovery near-transfer task and the discovery retention task (which as explained earlier is essentially a near-transfer task) do well on the retention task which is in the same category that they have experienced (addition). On the other hand, since the expository near-transfer subjects are trained with a specific rule in group I, they learn only this rule and not the solution category, therefore, they tend to treat a near transfer task like a far transfer task.

Turning to practice strategy VI, since the discovery near transfer students learn only the solution category, they may not be able to distinguish

new categories as the number increases and may persist in trying to fit the new cryptogram triplets into the old solution categories. Therefore, they perform poorly in condition VI. On the other hand, since the expository near transfer students learn specific rules, they are more likely to notice that the solution category has indeed changed when a new category is added. This increases their expectancy for additional new categories, so they do not persist as long in trying to make the new cryptogram triplets fit the old solution category rules.

One more question must be considered before we conclude our discussion. This question is concerned with the performance of the subjects trained with practice strategy IV. This group was exposed to three divergent solution categories with only one possible solution from each and they thus received only divergent practice.

The overall performance of this group when trained with the expository mode was significantly poorer than that for almost all other groups, while the performance with the discovery mode was relatively good. Although the level of performance in any one of the solution categories with the discovery mode was not particularly high, subjects were consistently successful at getting an overall average of slightly less than 1 solution per category. This is the same type of performance that one would expect from a group that had no training and corresponds closely to the pattern that was followed by the no training control group that was run simultaneously with the present study.

Those trained with the expository mode in Group IV seem to learn each of the three rules practiced very well as is indicated by the perfect score that each subject attained on the single retention item that they received in the final test (see Figure 2). However, the performance of this group

seems to be narrowly limited to applying only those rules taught, or at best a related rule. Only one subject in this group found any far transfer solution for any of the cryptograms and he was unable to discover the rule successfully.

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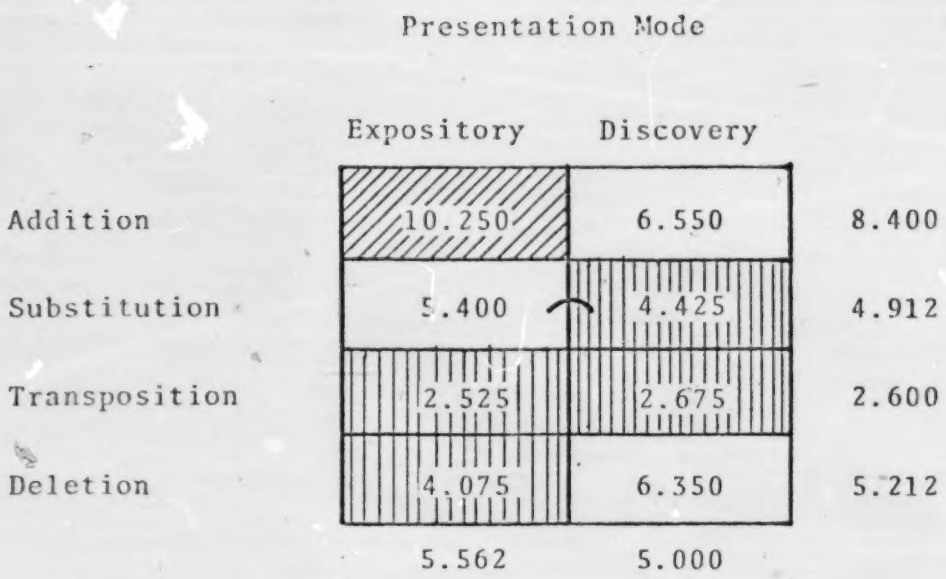
Practice Group		TYPE OF RULE: Addition (1)	Substitution (2)	Transposition (3)			Total Ieg's
I	Convergent Practice	$R_{11}R_{12}R_{13}$* (+18 Ieg's of CP)					18
II	Convergent Practice	$R_{11}R_{12}R_{13}$ (+9 Ieg's of CP)	$R_{21}R_{22}R_{23}$ (+9 Ieg's of CP				18
III	Convergent Practice	$R_{11}R_{12}R_{13}$ (+6 Ieg's of CP)	$R_{21}R_{22}R_{23}$ (+6 Ieg's of CP)	$R_{31}R_{32}R_{33}$ (+6 Ieg's of CP)			18
IV		R_{11}	R_{22}	R_{33}	Divergent Practice	(+18 Ieg's of DP)	18
V	Convergent Practice	$R_{11}R_{12}R_{13}$ (+3 Ieg's of CP)	$R_{21}R_{22}R_{23}$ (+3 Ieg's of CP)		Divergent Practice	(+12 Ieg's of DP)	18
VI	Convergent Practice	$R_{11}R_{12}R_{13}$ (+3 Ieg's of CP)	$R_{21}R_{22}R_{23}$ (+3 Ieg's of CP)	$R_{31}R_{32}R_{33}$ (+3 Ieg's of CP)	Divergent Practice	(+9 Ieg's of DP)	18

* Note: The first number in the subscripts identifies the rule type and the second number identifies the rule within the rule type.

Table 1. Constitution of the six practice groups used in the experiment.



Those cells with the same shading are not significantly different from each other, but they are significantly ($p<.05$) different from all cells with different shading. Note, however, that the two substitution cells, joined by the bridge, are not significantly different from each other.

Table 2. Estimated means for the presentation-mode x solution-category interaction.

SOLUTION CATEGORY

PRACTICE STRATEGY		Addition	Substitution	Transposition	Deletion	Means	Totals
Mixed Div Convergent	I	10.333	1.600	2.800	1.933	4.167	16.666
	II	11.214	9.071	3.357	9.714	8.339	33.356
	III	8.750	6.583	1.833	5.000	5.542	22.166
	IV	6.417	3.917	2.583	4.750	4.417	17.667
	V	7.000	4.231	0.692	4.077	4.000	16.000
	VI	6.214	4.357	4.071	5.857	5.125	20.499
	Means	8.400	4.912	2.600	5.212		

*p< .05

**p< .01

Using Duncans New Multiple Range Test

Table 3. Estimated means for the practice-strategy x solution-category interaction.

SOLUTION CATEGORY

PRACTICE STRATEGY		Addition		Substitution		Transposition		Deletion		Means		Means	Totals	
		Exp	Dis	Exp	Dis	Exp	Dis	Exp	Dis	Exp	Dis		Exp	Dis
Convergent	I	13.000	7.2857	2.0000	1.1428	2.8750	2.7143	3.0000	.7143	5.219	2.964	4.167	20.875	11.857
	II	12.714	9.7143	9.2857	8.8571	2.1428	4.5714	7.2857	12.143	7.857	8.821	8.339	31.428	35.286
Divergent	III	10.143	6.8000	6.2857	7.0000	2.7143	.5999	4.2857	6.0000	5.857	5.100	5.542	23.429	20.400
	IV	6.2000	6.5714	3.0000	4.5714	1.2000	3.5714	.7999	7.5714	2.800	5.571	4.417	11.200	22.286
Mixed	V	8.8333	5.4286	4.3333	4.1428	.0000	1.2857	3.6666	4.4285	4.208	3.821	4.000	16.833	15.286
	VI	8.8571	3.5714	7.1428	1.5714	5.4285	2.7143	4.5714	7.1428	6.500	3.750	5.125	25.200	15.000
Means		10.250	6.550	5.400	4.425	2.525	2.675	4.075	6.350					
Means		8.400		4.912		2.600		5.212						

* p<.05
** P<.01 Using Duncans New Multiple Range Test

Table 4. Estimated means for the presentation-mode x practice-strategy x solution-category interaction.

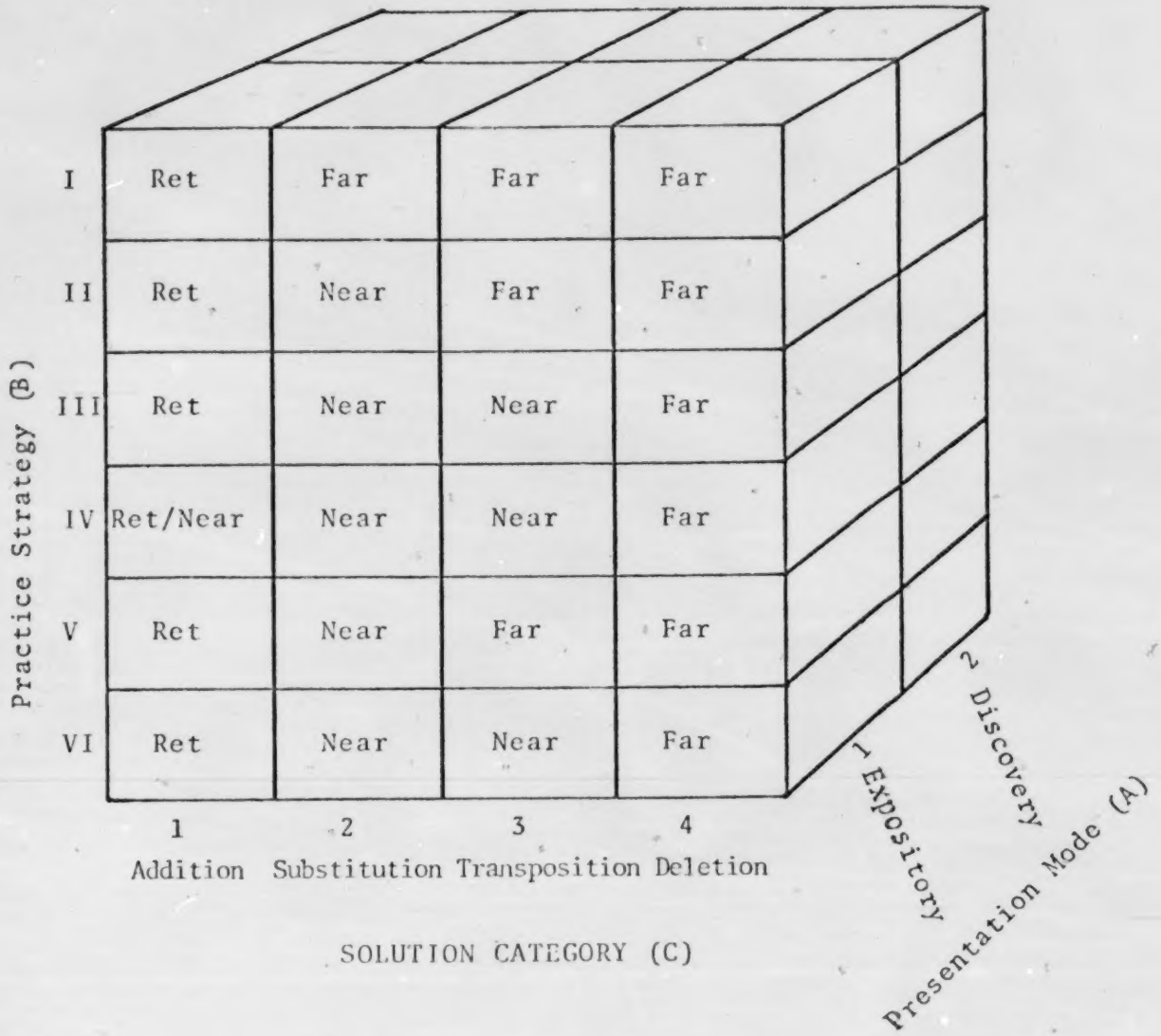


Figure 1. Model Diagram for the analysis of data and breakdown of the learning tasks measured by the different solution categories of the test.

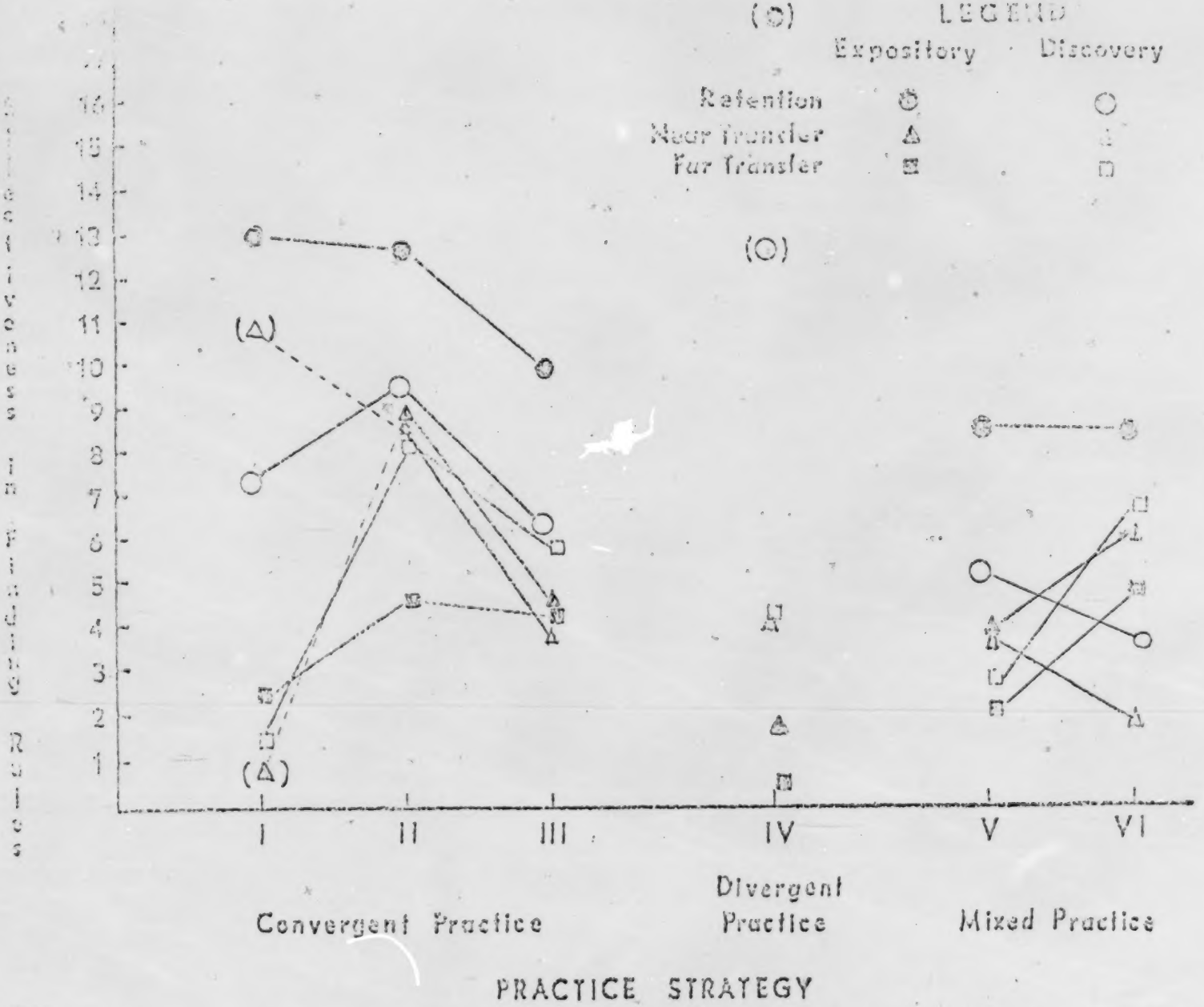


Figure 2. Graph of the practice-strategy data combining the solution categories into learning tasks.